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(54) **A pre-selector actuating device for a pre-selector in a tap changer**

(57) The invention relates to a pre-selector actuating device for a pre-selector in a tap changer of a transformer. The device includes a drive input means (11) arranged to make an input movement stroke of a predetermined length. Further it includes a pre-selector arm (51) arranged to make a pre-selector stroke from a first contact to a second contact. There is a movement transmission mechanism connected to the drive input means (11) and to the pre-selector arm (51).

According to the invention, the movement transmission mechanism is arranged to convert the input movement stroke such that the pre-selector stroke obtains a movement pattern having an initial period of relatively slow movement, an intermediate period of relatively fast movement and an end period of relatively slow movement.

The invention also relates to a tap changer having such a device and to a transformer provided with such a tap changer.

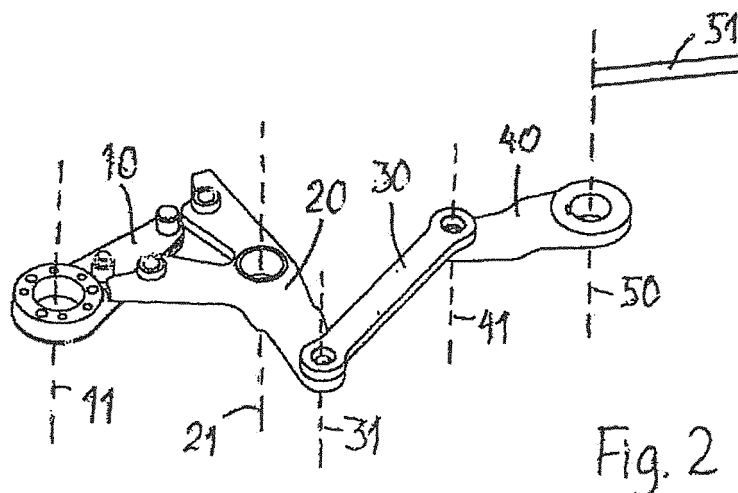


Fig. 2

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Description

Field of invention

[0001] The present invention relates to a pre-selector actuating device for a pre-selector in a tap changer of a transformer, which device includes a drive input means arranged to make an input movement stroke of a predetermined length, a pre-selector arm arranged to make a pre-selector stroke from a first contact to a second contact and a movement transmission mechanism connected to the drive input means and to the pre-selector arm.

[0002] The invention also relates to a tap changer and to a transformer.

Background of invention

[0003] A tap changer is commonly used in connection with a transformer in order to vary the transformation rate thereof. In a transformer with a tap changer one of the windings in the transformer has a fixed amount of turns connected to the circuit. The other winding has one fixed connection point, whereas the other connection point can be selected among a number of points to attain a required voltage. The selectable points may be located after each other along a portion of the winding corresponding to 70% to 100% of its full extension.

[0004] Upon a change in the load connected to the transformer or due to other influences it might be required to change the connection point. The need of changing the tap point is often triggered automatically in response to sensed parameters. Tap changing includes a plurality of manoeuvres including the opening and closing of switches e.g. via a spring loaded energy accumulator and moving a selector arm to a new connection point. These manoeuvres have to be performed in a certain sequence and in a certain time relation.

[0005] A tap changing manoeuvre includes the change of connection from one connection point to an adjacent connection point. This is performed by a pre-selector arm establishing the contact with the respective contact point. Illustrative examples of the actuation of the pre-selector arm are disclosed in DE 26202011, EP 2256769 and US 2009/0211890.

[0006] In the device of DE26202011 there is provided auxiliary contacts at higher voltage levels in order to reduce arc development when the pre-selector arm opens from the first contact point. In EP 2256769 a pair of springs act on the pre-selector arm to obtain a quick contact separation in order to quickly extinguish occurring arc.

Summary of invention

[0007] The actuation of the pre-selector arm according to prior art in general as well as in the examples mentioned above is accomplished with a generally constant speed and force of the selector arm. The actuating move-

ment which includes breaking from the starting contact point, travelling and contacting the other contact point, however is far from optimal since there are different demands on its velocity/force at different phases of the movement.

[0008] The object of the present invention is to attain a pre-selector actuating device that optimizes the movement pattern of the pre-selector arm.

[0009] This object is achieved in that a pre-selector actuating device of the kind mentioned in the introduction of the description includes the specific features that the movement transmission mechanism is arranged to convert the input movement stroke such that the pre-selector stroke obtains a movement pattern having an initial period of relatively slow movement, an intermediate period of relatively fast movement and an end period of relatively slow movement.

[0010] Thereby an adaption of the movement pattern to the different demands at various phases of the movement is achieved. At the beginning of the movement it is required to have a relatively strong force in order to overcome the high static friction between the contacts. After contact separation it is desirable to have a relative high velocity of the movement in order to decrease capacitive breaking time. The higher velocity during the intermediate period meets this demand. The lower velocity during the end period means that entering the fixed contact will be made at low velocity, which reduces the risk of bouncing. The predetermined movement pattern will also contribute to attain a tuned timing when entering the fixed contact.

[0011] According to a preferred embodiment of the invention, the drive input means includes a rotational element providing a rotational input movement stroke, and the pre-selector arm is rotatable.

[0012] A rotating pre-selector arm is the most common type of pre-selector. The device according to this embodiment therefore can be widely used without other changes in the design. Providing a transmission resulting in the specified movement pattern is also more simple than at other types of movement such as linear.

[0013] According to a further preferred embodiment, the initial period represents 5 - 20 % of the pre-selector stroke and the end period represents 5 - 20 % of the pre-selector stroke.

[0014] The duration of the initial period and the end period, respectively within these ranges correspond to what normally is optimal to meet the demands at the various phases of the movement. In many cases the optimal duration of each of the initial and end period is about 10 %, i.e. in the range of 8 - 12 %.

[0015] According to a further preferred embodiment, the mean velocity of the pre-selector arm during the intermediate period is at least twice as high as the mean velocity of the pre-selector arm during each of the initial period and the end period.

[0016] To benefit from the advantages of the present invention it is normally desirable to have a high difference

of the velocity of the different periods. However, the higher the difference is, the more complicated the transmission mechanism has to be. The lower limit for the velocity difference according to this embodiment is sufficient to attain the advantages to a substantial extent. Preferably, the velocity difference is still larger, such that the velocity during the intermediate period is at least three times that of the velocity during the initial and end periods. The velocity during the initial period and the end period does not necessarily the same. In contrary it is preferred that the velocity during the initial period is in the range of 30 - 60 % of that during the end period.

[0017] According to a further preferred embodiment, the movement transmission mechanism includes a drive arm rotating with the shaft and a pivotable linkage arm connected to the pre-selector arm, which drive arm has an abutment means arranged to act on a the linkage arm.

[0018] Through these arms the specific movement pattern can be achieved with relatively simple mechanical measures relating to the cooperation of these arms.

[0019] According to a further preferred embodiment, the abutment means includes a first abutment unit and a second abutment unit, which abutment units are attached at different radial positions of the drive arm, and the linkage arm has a cam surface means arranged to cooperate with each of the abutment units.

[0020] Providing two such abutment units cooperating with the cam surface means facilitates to obtain the different velocities. Preferably the outer abutment unit is located at a radius that is in the range of 2 - 3 times the radius of the location of the inner abutment unit..

[0021] According to a further preferred embodiment, each abutment means is a roller.

[0022] Thereby rolling contact with the cam surface means is obtained, which reduces wear and friction losses. The rolling contact also results in higher accuracy and reliability.

[0023] According to a further preferred embodiment, the cam surface means is arranged to be in contact with the radially inner abutment unit during the initial period and to be in contact with the radially outer abutment unit during the intermediate period and the end period.

[0024] Since the lever distance to the radially inner abutment is relatively short the transmitted force will be relatively high and the velocity relatively low. Thereby the high force to overcome the static friction between the pre-selector arm and the contact from which it is to be braked is achieved in a simple way.

[0025] According to a further preferred embodiment, the cam surface means includes a first cam portion means arranged to cooperate with the first abutment unit and a second cam portion means arranged to cooperate with the second abutment unit.

[0026] Thereby a simple and appropriate adaption of the cam surface means to the provision of two abutment units is achieved.

[0027] According to a further preferred embodiment, the first cam portion means is located at a larger radial

distance from a pivot axis of the linkage arm than the second cam portion means.

[0028] This relative location of the cam portions further adapts the cam surface means to a constructionally simple cooperation with the two abutment units and results in a smooth transmission.

[0029] According to a further preferred embodiment, the first cam portion means includes at least one cam section having the shape of a concave arc, and the radial extension of the second cam portion means is at least twice as large than the radial extension of said at least one cam section.

[0030] These features in a simple manner make the cam surface means still further suitable for a smooth cooperation with the abutment units of the drive arm.

[0031] According to a further preferred embodiment, the drive input means is arranged to be able to rotate in either direction for rotating the pre-selector arm in either direction.

[0032] Tap changing from one contact point to an adjacent contact may occur to either of the two adjacent contact points which are located at opposite sides. This requires that the pre-selector arm can be moved in either direction. By this embodiment this is made possible through one and the same transmission means without requiring any further constructional components.

[0033] According to a further preferred embodiment, the second cam portion has a U-shape, the cam surface means is symmetrical in relation to a line intersecting the middle of the U-shaped second cam portion means perpendicular to a bottom thereof, and the first cam portion means includes two cam sections located at each side of the U-shaped second cam portion means, which cam sections have identical shape except from being mirrored in relation to each other.

[0034] This embodiment is particularly suitable for allowing the pre-selector arm to move in either direction. The symmetry of the cam surface means assures an identical movement pattern in either direction. The U-shaped second cam portion thereby is active in either direction, whereas each of the two cam sections is active only in one direction.

[0035] The object of the present invention is further met in that a tap changer includes a pre-selector actuating device according to the present invention, in particular to any of the preferred embodiments thereof. The object of the present invention is also met in that a transformer includes a tap changer according to the present invention.

[0036] The invented tap changer and transformer gain from the advantages of the invented pre-selector arm actuating device and the preferred embodiments thereof, which advantages have been described above.

[0037] The above described preferred embodiments of the invention are specified in the dependent claims. It is to be understood that further preferred embodiments of course can be constituted by any possible combination of the preferred embodiments above and by any possible

combination of these and features mentioned in the description of examples below.

[0038] The invention will be further explained through the following detailed description of examples thereof and with reference to the accompanying drawings.

Short description of the drawings

[0039]

Fig. 1 a - 1 c schematically illustrates a tap changer for which the device of the present invention is suitable.

Fig. 2 is a view in perspective of the movement transmission mechanism according to the present invention.

Fig. 3 is a plan view of a part of the movement transmission mechanism shown in fig. 2 and illustrates the mechanism at a starting position.

Figures 4-8 are views corresponding to that of fig. 3 illustrating the mechanism at different consecutive stages of the movement transmission.

Fig. 9 in a plan view corresponding to that of fig. 3 illustrates the mechanism at the end position.

Fig. 10 is a graph illustrating the movement pattern of the pre-selector arm according to the invention.

Description of examples

[0040] Fig 1a - 1c schematically illustrates a tap changer. Fig. 1 a is a single-phase diagram of a tap changer 100 of a kind for which the device according to the present invention is intended. The tap changer 100 is connected to a regulating winding of a transformer and has a set of different taps 102, in this case the number of taps is 16, but the number might be some other, for example any number from 5 to 35.. The tap changer of fig. 1a is of diverter switch type, and comprises a diverter switch 120 and a tap selector 110.

[0041] The tap selector 110 of Fig.1 operates with pre-selection and fine selection, and thus comprises a pre-selector arm 51 and a fine selector shaft including the two arms 101 & 102. Both the pre-selector arm 51 and the fine selector shaft operate by a respective rotational movement, moving the pre-selector arm 51 as illustrated in fig 1b and fine-selector arms 101 and 102 as in fig 1 a & 1 c. Movement of fine selector arms 101 and 102 occurs when V or H in diverter switch 120 is disconnected, as illustrated in fig 1 a. The pre-selector arm 51 is moved between contact 22 to contact 21 during the period where fine selector arm 102 is moved from contact 14 to contact 16.

[0042] The fine selector arms 101 and 102 can respectively be brought into contact with either of 8 different fixed contacts and in combination with pre-selector arm 51, totally 16 taps are available for this coarse/fine switching configuration.

[0043] The diverter switch 120 in a known manner has

a set of breakers, e.g. vacuum breakers. When it is required to change from one tap to another, these breakers are opened and closed in a certain sequence. This allows the selector arms 51, 101 to respectively move from one fixed contact to an adjacent fixed contact.

[0044] Fig. 2 in a perspective view shows the actuating device for the pre-selector arm. Its two main components are the drive arm 10 and the linkage arm 20. The drive arm 10 is connected to a Geneva wheel, represented in the figure by its axis 11 and constitutes the drive input 11 of the device. The drive arm 10 is fixedly attached to the Geneva wheel, e.g. by means of rivets. The Geneva wheel forms a part of a gearbox arranged to provide movements for the switch diverter and the tap selector in a predetermined timing sequence for tap changing. The gearbox receive drive input from a motor upon tap changing command. The construction of the gearbox may be of any conventional type and is supposed to be superfluous to explain for the purpose of the present invention.

[0045] The linkage arm 20 is via levers 30 and 40 in driving connection with a shaft, represented in the figure by its axis 50. The shaft 50 is drivingly connected to the rotatable pre-selector arm 51.

[0046] When the pre-selector arm 51 is to be actuated, the Geneva wheel 11 rotates a certain angle providing an input movement stroke, which normally is a little less than 70° and at constant rotational velocity. The drive arm 10 thereby rotates uniformly with the Geneva wheel. The linkage arm 20 is pivotable around a pivot axis 21. The drive arm 10 cooperates with the linkage arm 20 to transmit rotational movement to the latter. The cooperation between these two elements is such that the moving pattern of the linkage arm 20 deviates from that of the drive arm 10 in a predetermined way. This is achieved by a specific construction of those parts of the drive arm 10 and the linkage arm 20 that come in contact with each other and will be explained more in detail further below with reference to figures 3 to 9.

[0047] The lever 30 is rotatably connected to the linkage arm around an axis 31 and is rotatably connected to the lever 40 around an axis 41. Thereby rotational movement of the linkage arm 20 results in a corresponding rotational movement of the lever 40. The lever 40 is drivingly secured to the shaft 50 such that the pre-selector arm 51 will rotate in uniform with the lever 40.

[0048] Referring now to figures 3 to 9 the movement transmission between the drive arm 10 and the linkage arm 20 will be explained more in detail.

[0049] Fig. 3 shows the drive arm 10 and the linkage arm 20 at a position before movement starts. The drive arm 10 has abutment means 12, 13 consisting of a radially inner abutment unit 12 and a radially outer abutment unit 13. Each of the abutment units 12, 13 is a roller.

[0050] The linkage lever 20 is fork-shaped with two legs 22a, 22b on which the cam surface means 23a, 23b, 24a, 24b is provided. The cam surface means 23a, 23b, 24a, 24b consists of a radially outer cam portion means

23a, 23b and a radially inner cam portion 24a, 24b.

[0051] The first cam portion means 23a, 23b consists of a first cam section 23a and a second cam section 23b located at the outer end of the respective leg 22a, 22b. The two cam sections 23a, 23b have the same shape except from being mirrored in relation to each other. The shape of each of the cam sections 23a, 23b includes a concave arc around the middle of the respective cam section. The arc might be a circular arc but can alternatively have a varying radius.

[0052] The second cam portion 24a, 24b is generally U-shaped and consists of two identical branches 24a, 24b that meet each other at the middle of the bottom part of the U-configuration. At the bottom of the U-configuration the second cam portion 24a, 24b has an arc-shape 241 a, 241 b that in the shown figure is circular but can alternatively have another arc-shape. From the bottom part of the U-configuration the second cam portion 24a, 24 has a continuation 242a, 242b on each side as a straight line, which lines can be parallel or somewhat diverging outwardly. At the outer end of the continuations the cam surface has a respective convex part 243a, 243b.

[0053] A straight line L through the middle of the U-configuration perpendicular to the bottom symmetrically divides the cam means 23a, 23b, 24a, 24b.

[0054] From the starting position illustrated in fig. 3 the drive arm 10 is arranged to rotate clockwise a certain angle, whereby the linkage arm 20 will rotate in the counter-clockwise direction. First the drive arm 10 moves without touching the linkage arm 20.

[0055] After a short while the position shown in Fig. 4 is reached. Now the inner roller 12 starts to contact the cam portion 23a. The linkage level thereby will start to rotate, whereby the roller 12 rolls on the cam section 23a. Since the radius to the roller 12 is relatively short the driving force will be strong and the velocity of the linkage arm relatively low. The cooperation between roller 12 and cam section 23a represent an initial period of the movement transmission. The strong force transmitted during this period facilitates to overcome the static friction when separating the pre-selector contacts.

[0056] After a further rotation of the drive arm 10 the outer roller 13 thereof will come into contact with the inner cam portion at the part 24a thereof adjacent the bottom of the U-configuration. Driving thereby will be accomplished by the cooperation of these elements. At this moment the pre-selector arm has left the fixed contact point. Since the radius to the roller 13 is much larger than that to the roller 12, the gear ratio changes and the linkage arm 20 will rotate at much higher velocity. This contributes to a quick increase of the distance between the moving and fixed contacts, i.e. the capacitive braking is quick. This represents an intermediate period of the movement transmission.

[0057] Fig. 5 illustrates the position of the components at the beginning of this intermediate period. Due to the higher velocity of the linkage arm 20 during this period, the inner roller 12 leaves the contact with the cam section

23a. In this figure this has just occurred.

[0058] Fig. 6 illustrates the position of the components at a later stage during the intermediate period. The contact point between the roller 13 and the cam portion part 24a has moved slightly from the middle of the bottom of the U-configuration resulting in a corresponding reduction of the velocity of the linkage arm 20. The velocity however is still high in relation to that of the initial period.

[0059] Fig. 7 illustrates the next step. After further rotation of the drive arm 10 the contact point between the outer roller 13 and the cam portion part 24a travels further outwards along the continuation 242a. This results in a further reduction of the velocity of the linkage arm 20.

[0060] Fig. 8 illustrates the position of the components at an end period of the movement transmission. During the end period the contact point between the roller 13 and the cam part 24a at the very outer end of the latter, i.e. where it has the convex part 243a. During this period the velocity of the linkage arm 20 is substantially reduced. Thereby the contact of the pre-selector will reach the fixed contact at low speed, reducing the risk of bouncing.

[0061] In fig. 9 the movement is completed. The components have a position that is symmetrical to that of the starting position illustrated in fig. 3 and the device is ready for an actuating movement in the reversed direction. This is accomplished in the same way as has been described above. The rollers will then cooperate with the cam section 23b and the cam part 24b.

[0062] Fig. 10 is a graph illustrating the movement pattern of the pre-selector arm 51 actuated by the device described above. The graph is based on a simulation and thus is a principal representation, from which minor deviations might be present in practice. It shows the velocity of the pre-selector arm in degrees/second as a function of angle of the pre-selector arm. During the initial period at braking from the first fixed contact the velocity is about 25 degrees/sec. This period occurs during the first 10 degrees of the pre-selector arm movement, and the movement is transferred from the inner roller 12 of the drive arm 12 as explained in relation to fig. 4.

[0063] After this initial period the velocity of the pre-selector arm increases almost instantly to over 200 degrees/sec. This occurs when the driving has shifted from the inner roller 12 to the outer roller 13. After reaching this maximum, the velocity slowly decreases during the intermediate period down to about 50 degrees/sec. This velocity is reached after about 90 degrees rotation of the pre-selector arm. At this stage the end period begins and lasts until contact with the fixed contact is established at 100 degrees rotation of the pre-selector arm. The velocity during the end period is substantially constant at 50 degrees/sec. This velocity is sufficient to avoid bouncing when the pre-selector arm contacts the fixed contact.

Claims

1. A pre-selector actuating device for a pre-selector in

- a tap changer of a transformer, which device includes a drive input means (11) arranged to make an input movement stroke of a predetermined length, a pre-selector arm (51) arranged to make a pre-selector stroke from a first contact to a second contact and a movement transmission mechanism connected to the drive input means (11) and to the pre-selector arm (51), **characterized in that** the movement transmission mechanism is arranged to convert the input movement stroke such that the pre-selector stroke obtains a movement pattern having an initial period of relatively slow movement, an intermediate period of relatively fast movement and an end period of relatively slow movement.
2. A pre-selector actuating device according to claim 1, **characterized in that** the drive input means (11) includes a rotational element providing a rotational input movement stroke and that the pre-selector arm (51) is rotatable.
 3. A pre-selector actuating device according to claim 1 or 2, **characterized in that** the initial period represents 5 - 20 % of the pre-selector stroke and that the end period represents 5 - 20 % of the pre-selector stroke.
 4. A pre-selector actuating device according to any of claims 1-3, **characterized in that** the mean velocity of the pre-selector arm (51) during the intermediate period is at least twice as high as the mean velocity of the pre-selector arm (51) during each of the initial period and the end period.
 5. A pre-selector actuating device according to any of claims 2-4, **characterized in that** the movement transmission mechanism includes a drive arm (10) rotating with the rotational element and a pivotable linkage arm (20) connected to the pre-selector arm (51), which drive arm (10) has an abutment means (12, 13) arranged to act on the linkage arm (20).
 6. A pre-selector actuating device according to claim 6, **characterized in that** the abutment means (12, 13) includes a first abutment unit (12) and a second abutment unit (12, 13), which abutment units are attached at different radial positions of the drive arm (10) and **in that** said linkage arm (20) has a cam surface means (23a, 23b, 24a, 24b) arranged to cooperate with each of the abutment units (12, 13).
 7. A pre-selector actuating device according to claim 6, **characterized in that** each abutment unit (12, 13) is a roller.
 8. A pre-selector actuating device according to claim 6 or 7, **characterized in that** the cam surface means (23a, 23b, 24a, 24b) is arranged to be in contact with the radially inner abutment unit (12) during the initial period and to be in contact with the radially outer abutment unit (13) during the intermediate period and the end period.
 9. A pre-selector actuating device according to any of claims 6-7, **characterized in that** the cam surface means (23a, 23b, 24a, 24b) includes a first cam portion means (23a, 23b) arranged to cooperate with the first abutment unit and a second cam portion means (24a, 24b) arranged to cooperate with the second abutment unit.
 10. A pre-selector actuating device according to claim 9, **characterized in that** the first cam portion means (23a, 23b) is located at a larger radial distance from a pivot axis (21) of the linkage arm (20) than the second cam portion means (24a, 24b).
 11. A pre-selector actuating device according to claim 9 or 10, **characterized in that** the first cam portion means (23a, 23b) includes at least one cam section having the shape of a concave arc and **in that** the radial extension of the second cam portion means (24a, 24b) is at least twice as large than the radial extension of said at least one cam section.
 12. A pre-selector actuating device according to any of claims 2-11, **characterized in that** the drive input means (11) is arranged to be able to rotate in either direction for rotating the pre-selector arm (51) in either direction.
 13. A pre-selector actuating device according to claim 12, when depending from claim 11, **characterized in that** the second cam portion means (24a, 24b) has a U-shape, **in that** the cam surface means (23a, 23b, 24a, 24b) is symmetrical in relation to a line (L) intersecting the middle of the U-shaped second cam portion means (24a, 24b) perpendicular to a bottom thereof, **in that** the first cam portion means (23a, 23b) includes two cam sections located at each side of the U-shaped second cam portion means (24a, 24b), which cam sections have identical shape except from being mirrored in relation to each other.
 14. A tap changer, **characterized in that** the tap changer (100) includes a pre-selector actuating device according to any of claims 1-13.
 15. A transformer, **characterized in that** the transformer includes a tap changer according to claim 14.

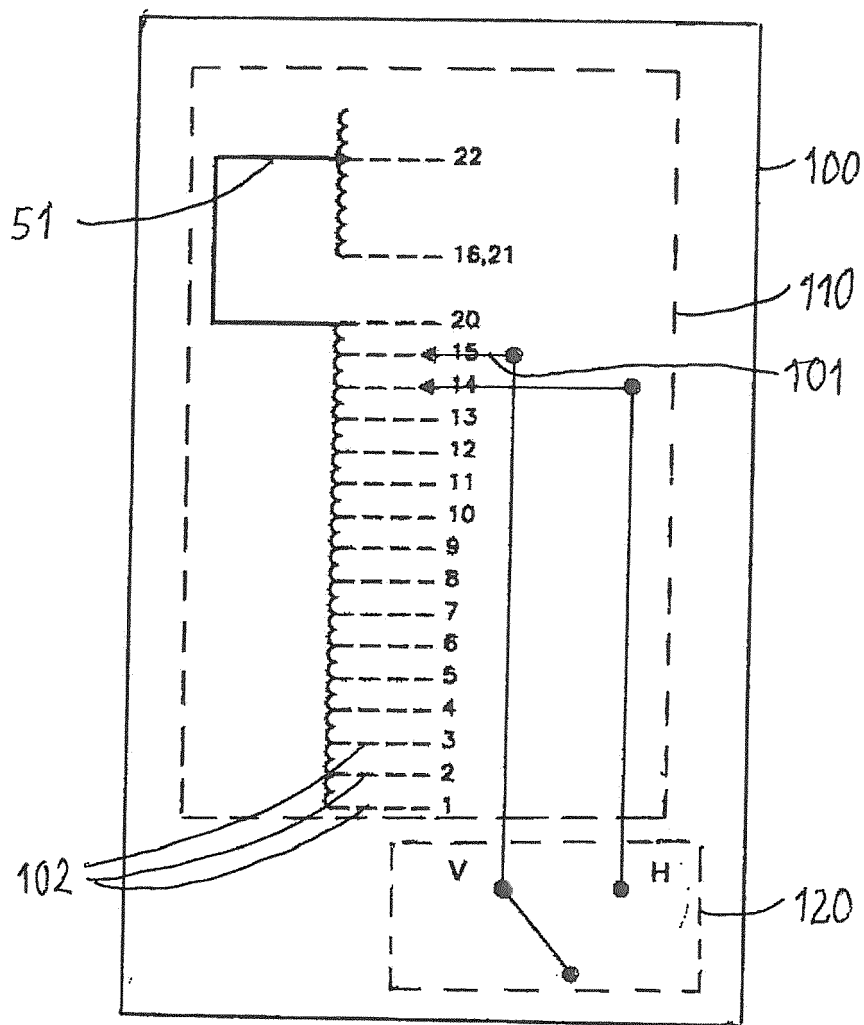


Fig. 1a

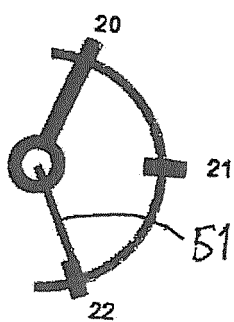


Fig. 1b

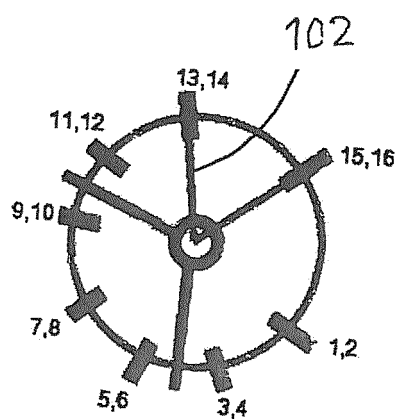
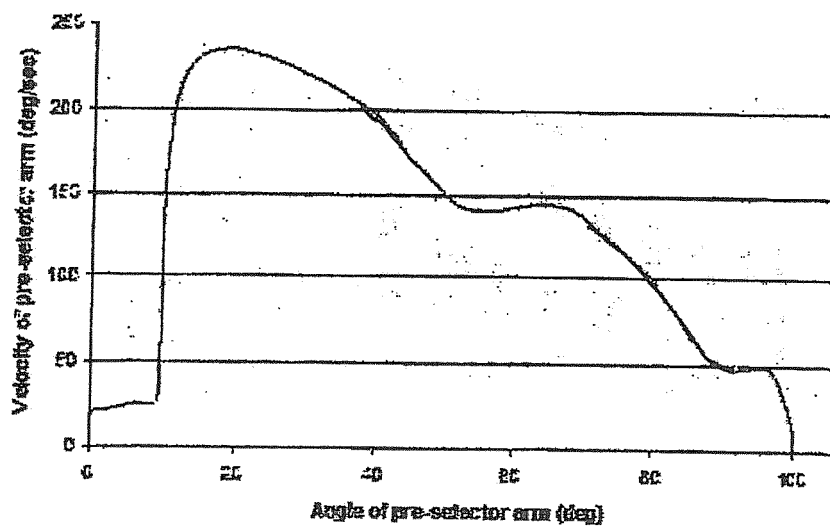
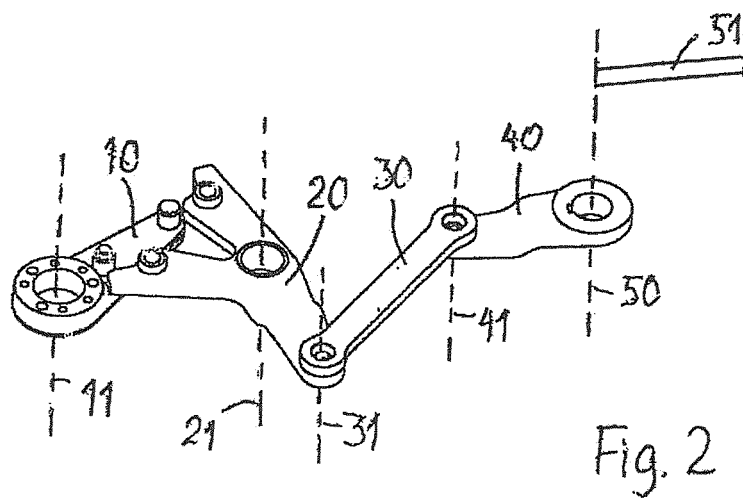


Fig. 1c



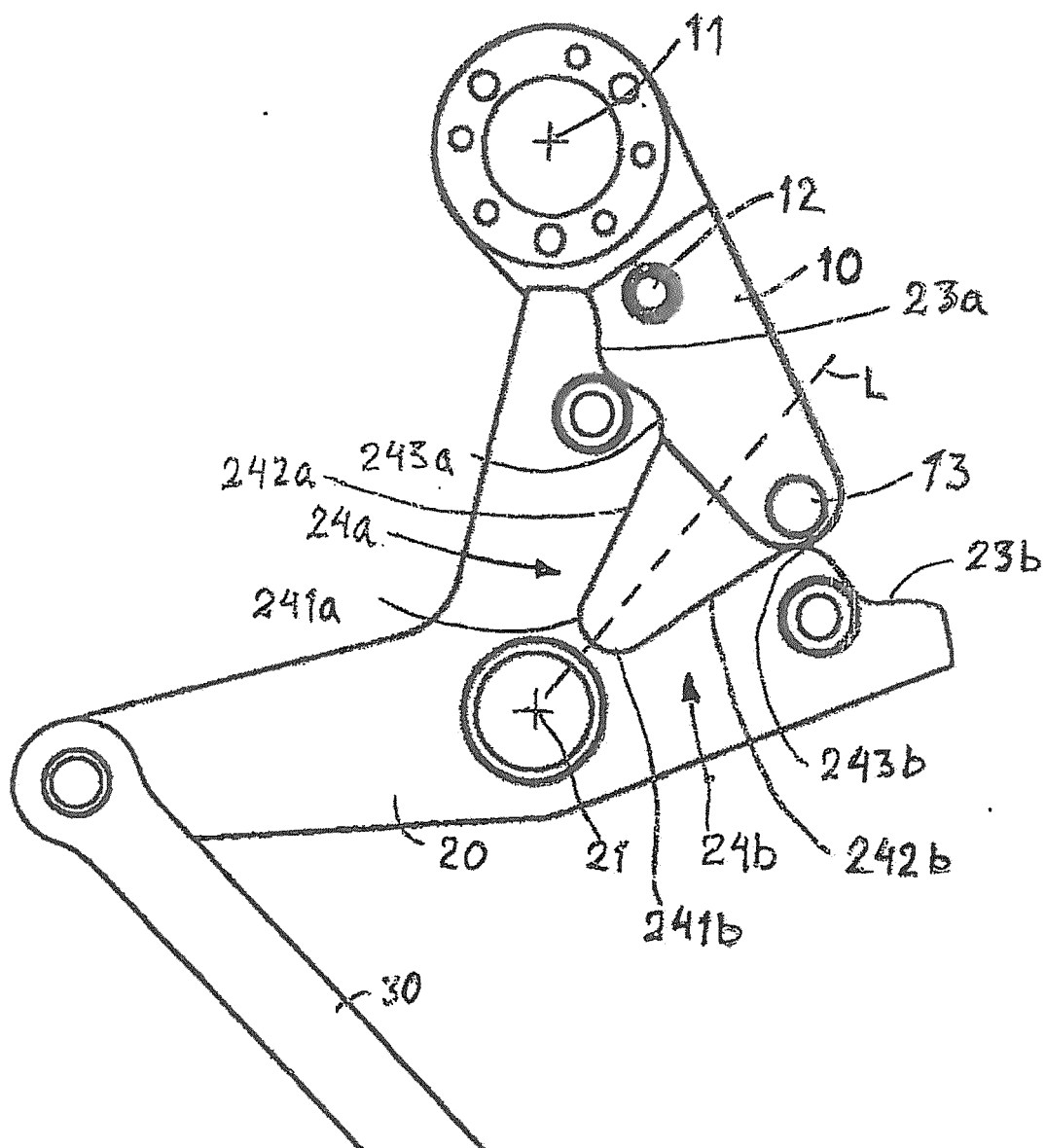


Fig. 3

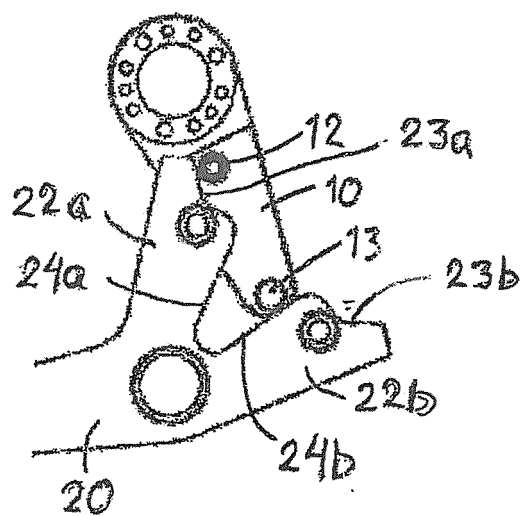


Fig. 4

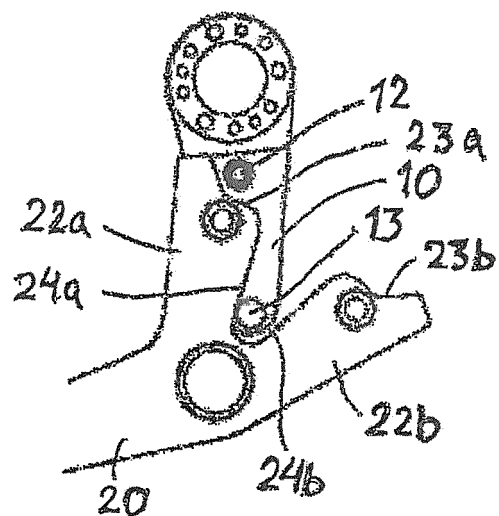


Fig. 5

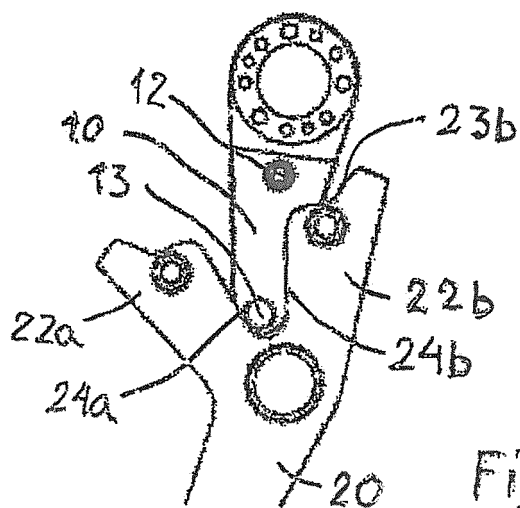


Fig. 6

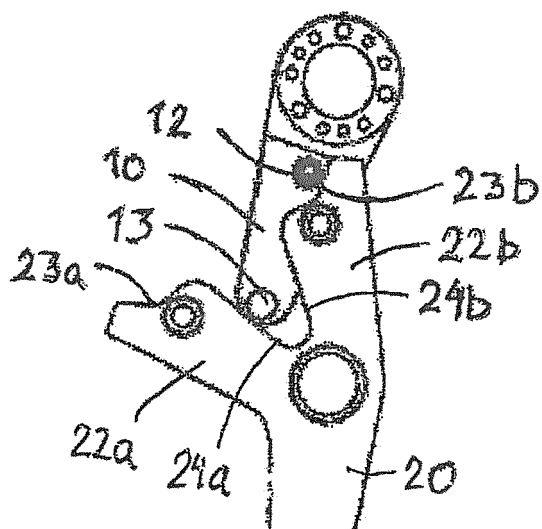


Fig. 7

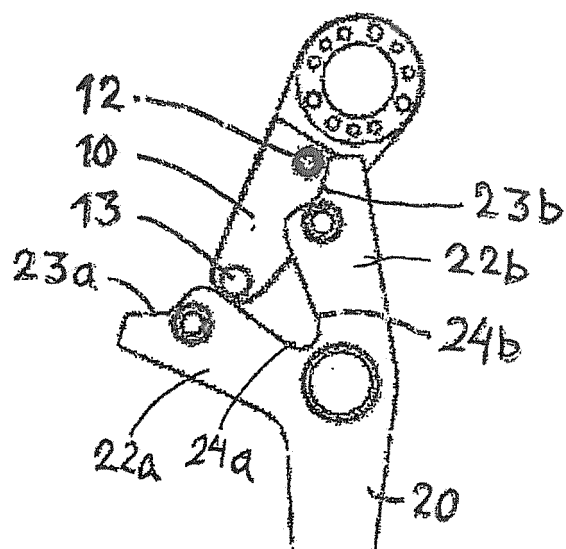


Fig. 8

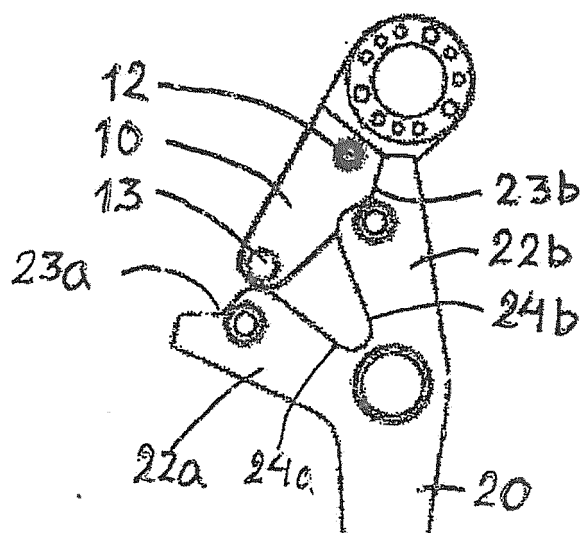


Fig. 9



EUROPEAN SEARCH REPORT

Application Number
EP 11 18 5882

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 155 782 A (WILSON JR GORDON A) 3 November 1964 (1964-11-03)	1-9,14, 15	INV. H01H9/00
Y	* column 1, line 40 - column 9, line 67; figures 1-4 *	10-13	
X	GB 697 558 A (SMIT & WILLEM & CO NV) 23 September 1953 (1953-09-23)	1,2,14, 15	
A	* page 1, line 21 - page 2, line 45; figures 1,2 *	3-13	
Y	DE 24 51 608 A1 (ACEC) 15 May 1975 (1975-05-15)	10-13	
A	* page 3, paragraph 1 - page 1, paragraph 1; figure 1 *	1-9,14, 15	
Y	DE 757 517 C (AEG) 7 December 1953 (1953-12-07)	10-13	TECHNICAL FIELDS SEARCHED (IPC) H01H
A	* page 2, line 6 - line 56; figure 1 *	1-9,14, 15	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 24 February 2012	Examiner Pavlov, Valeri
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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